SOLVED AND UNSOLVED PROBLEMS IN DYNAMICAL METEOROLOGY

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The motion of the atmosphere should be one of the most obvious applications of theoretical hydrodynamics. But up to date it has not been so. The main reason is that attention has been directed almost exclusively to fluids of which the properties have been too strongly idealized. In this connection the omission of friction is unimportant. The main thing is that the equation

\[ \rho = f(p) \]

has generally been adhered to (\( \rho \) density, \( p \) pressure). Thereby the connection with thermodynamics is cut off; the consideration of the origin of atmospheric motions is completely excluded; the general principle of the absolute conservation of vortex motion is obtained, which leads to such a striking contradiction to everyday meteorological experience.

The deciding step will therefore always be to start with the true equation

\[ \rho = f(p, \theta, h) \]

(\( \theta \) temperature, \( h \) humidity). After this hydrodynamics can exert its influence upon the development of meteorology along the following two lines:

I. By furnishing meteorologists with hydrodynamic laws in a form in which they can be applied directly to the actual meteorological situations or processes.

II. By solving special problems which contribute to the general understanding of the dynamics of the atmosphere.

In line I. the barometric formula, the principle of the "geostrophic wind," and the laws of the vortex formation (which contain as special cases the Helmholtz-laws of their conservation) have been important hydrodynamic contributions to meteorological work. The ultimate aim of this kind of work will be to arrive—at least in theory—at a mathematical method of weather forecasting, based upon a direct application of the hydrodynamic and thermodynamic laws to the situations represented by the weather chart. Even if this aim should never be reached, the attempt within the limits of possibility to treat the problem of the weather forecasting as if it were a mathematical problem can only react favourably upon the progress of this work. In reality
it has already done so to a considerable extent (cf. the progress connected
with the discovery of the polar front phenomena and their utilization in the
forecasting work).

For the mathematician the progress along line II. will be the more interest­
ing, as it will furnish him with important problems. The main thing is to
formulate the problems in such a way that from the meteorological side we
reach our goal and from the mathematical side we do not encounter difficulties
impossible to overcome. This may be realized in the following way:

In the first approximation we consider the great atmospheric motions as
steady motions going on very slowly. This is legitimate because the barometric
formula, although a formula of hydrostatics and not of hydrodynamics, is
fulfilled with a very high degree of approximation during all great atmospheric
motions.

In the second approximation we consider the consequence of small dis­
turbances of this steady state of motion.

In this way we arrive at problems defined by linear equations with
which we can hope to proceed mathematically; and what is equally important,
it can be foreseen by elementary qualitative methods that in this way we shall
arrive at a rational treatment of the most central problem in dynamical
meteorology, that of the extratropical moving cyclones and anticyclones.

The paper was illustrated by diagrams and models.

NOTE: For more detailed information both with regard to subjects treated in the paper whose
abstract is herewith printed and with regard to the contents of the other paper presented to the
Congress under the title "The Forces that Lift Aeroplanes" the reader may consult the following
two papers by Professor Bjerknes:

Le problème des Cyclones, Jour. de Physique, Paris, Nov., 1924.

Sur les forces qui portent les aéroplanes et leur relation avec les actions hydrodynamiques à

The complete contents of the author’s two Congress papers together with further
developments will also be found included in a course of lectures delivered under the title
"Physical Hydrodynamics" at the California Institute of Technology in Pasadena during the
Fall of 1924.